Newsletter No. 1 August 1, 1982

# IHW
# INTERNATIONAL HALLEY WATCH

# THE GOALS OF THE INTERNATIONAL HALLEY WATCH

## Advocacy

The IHW will encourage and support any scientifically valid means of studying Comet Halley.

## Coordination

The IHW will coordinate activities among the ground-based disciplines and with flight projects in order to maximize the scientific value of the entire body of observations.

## Standardization

The scientists in each IHW discipline will set useful standards for observations in that discipline. There is no absolute requirement that such standards be followed for IHW participation, however.

## Archiving

All properly documented data (reduced data, not interpretations) will be published in a Halley Archive in 1989. This Archive will complement the usual interpretive papers in the open literature, not supplant them.

THE INTERNATIONAL HALLEY WATCH NEWSLETTER

Issue No. 1 August 1, 1982

IHW Leader: Ray L. Newburn

IHW Co-Leader for Europe, Africa, and Asia: Jurgen Rahe

IHW Deputy Leader: Murray Geller

IHW Newsletter Editor: Stephen J. Edberg

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## EDITORIAL

This is the first IHW Newsletter. It is intended to acquaint readers with the organization and plans of the International Halley Watch as it prepares for the 1986 apparition of Halley's Comet. Interested observers are encouraged to fill out and return the forms at the end of this newsletter to the appropriate Discipline Specialists. Readers desiring to receive future issues of this newsletter should return the appropriate form to the Lead Center.

Future issues will appear on an irregular or quarterly basis. Our hope is to maintain open lines of communication between the IHW Lead Center, Discipline Specialists, observers, flight projects, and other interested readers. We invite short contributions on scientific, instrumental, or social aspects of preparations for the Halley apparition. Please submit items of interest to the editor at the address below.

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HISTORY OF THE INTERNATIONAL HALLEY WATCH

The original concept of an International Halley Watch (IHW) belongs to Louis Friedman, then of the Jet Propulsion Laboratory (JPL). It was first proposed to the United States National Aeronautics and Space Administration (NASA) by him in the summer of 1979. The intent was to maximize the scientific value of ground-based and space studies of Halley and to avoid the problems of 1910. With a small grant to study the idea, Friedman recruited three JPL astronomers to help him, Jay Bergstralh, Don Yeomans, and Ray Newburn. Bergstralh looked at possible studies from Earth orbit, particularly using the space shuttle. (It now appears such studies have a good chance of occurring.) Yeomans concentrated on astrometry and the ephemeris, the geocentric aspects of the 1986 apparition, and the history of Comet Halley. Newburn concentrated on general ground-based scientific goals and the kind of organization that might meet them. Friedman himself managed the study and was especially concerned with space flight to Halley and ground-based needs of flight programs as well as "selling" the overall concept.

During the early study phase, contact was made with scientists at Goddard Space Flight Center where John Brandt, Jurgen Rahe (visiting from the University of Erlangen-Nürnberg in West Germany), and collaborators had already proposed worldwide cooperation in the ground-based study of Halley's ion tail as a supporting part of the proposed Halley-Tempel 2 International Comet Mission. These scientists strongly supported the IHW concept in discussions with NASA.

During the winter of 1980 NASA created a Science Working Group of a broad cross section of US cometary scientists and the JPL study team under the chairmanship of John Brandt. This working group met at Goddard Space Flight Center in March and again in May of 1980, working to refine the IHW concept. Observers from the European Space Agency (ESA) attended the March meeting, having been apprised the previous fall that a Halley Watch study was under way. The Working Group agreed that success of the IHW depended upon emphasis on the word International, that every effort should be made to recruit non-U.S. scientists in key positions. An outline of the IHW based upon Working Group modifications to the JPL Study Group plans was published in July, 1980 (1). This outline became the basis for preproject funding of the IHW by NASA and the inclusion of the IHW in specific proposals to the U.S. Congress for continued funding.

In the late summer of 1980 several important changes occurred. Friedman decided to leave JPL to become Executive Director of The Planetary Society, and Newburn became Study Leader. Then NASA made the decision to attempt to proceed with the IHW, designated JPL as the Lead Center for U.S. activity, and named Newburn as Acting IHW Leader. In late October 1980 Friedman and Newburn gave the first public paper on the new IHW at an international conference (2). Meanwhile, efforts were under way to bring Rahe into the IHW at the highest possible level. He played a major role both in developing the IHW concept and in selling it to NASA and to various U.S. scientific advisory boards. The IHW needed his specific knowledge of Halley, his international perspective, and his diplomatic abilities as well as his broad knowledge of general cometary science.

Early in 1981 NASA began asking scientists to serve on an international Steering Group. In a few cases the person invited suggested a more suitable colleague, but there were no outright rejections. The complete group is listed in another article, "Organization and Staff of the IHW." The Steering Group met for the first time April 30 and May 1, 1981. Meanwhile Newburn circulated 4500 copies of a "Dear Colleague" letter asking cometary specialists to propose to become Discipline Specialists in one of seven technical areas. These proposals were evaluated by the Steering Group, and Discipline Specialists were selected at the second Steering Group meeting November 11-13, 1981.

Although no public announcement of the IHW had been made, discussions of the IHW were presented at a number of scientific meetings during 1981 including the International Comet Conference in Tucson in March, the European IAU Regional Meeting in Dubrovnik in October, and the American Astronomical Society Division of Planetary Sciences meeting in Pittsburgh in October. In each case criticism of the IHW organization and plans were earnestly solicited. Meanwhile application was made to the IAU Executive Council (through Commission 15) for recognition of the IHW as coordinating body for Halley ground-based observations during the 1986 apparition. The reply to the chairman of Commission 15 on August 12, 1981 stated that "The proposal to recognize International Halley Watch as a comprehensive coordination program was accepted enthusiastically by the IAU Executive Council."

During 1981 the final form of the Lead Center organization evolved with Newburn appointed IHW-Leader and Rahe appointed IHW-Co-Leader. Two offices were established: a Pasadena, U.S.A., office managed by Newburn, and a Bamberg, FRG, office managed by Rahe. Operation of the Pasadena office is funded by NASA, and operation of the Bamberg office is supported by the Federal Republic of Germany. As mentioned earlier, details of organization and staff will be found in other articles in this newsletter.

As originally conceived by Friedman the IHW was to be closely tied to the Halley flight projects. In September 1981 these ties became reality at the first meeting of the Interagency Consultative Group (IACG) in Padua, Italy. Delegations from ESA, the Soviet Union, Japan and NASA met there to discuss ways to maximize the scientific output of all the Halley studies. Recognizing the importance of setting the spacecraft results into the larger context of the entire apparition and the need for astrometric data and improved ephemerides, the IACG delegations at Padua recognized the IHW as a necessary partner in their activities and agreed to a full exchange of data for the Archive, which will be the ultimate output of the IHW. Project Representatives, who serve as the link between IHW and IACG, were appointed by the projects in late May and early June of 1982.

Discipline Specialist teams were essentially complete by May, 1982. Contracts from JPL for support of U.S. team members were effective July 1, 1982. This set the stage for the formal announcement of the IHW here at the best possible forum, the triennial meeting of the International Astronomical Union. This Newsletter is the first issue of an organ of general communication for those scientists who participate in the IHW.

R. Newburn

(1) The International Halley Watch, Report of the Science Working Group, NASA TM 82181, July 1980.

(2) Modern Observational Techniques for Comets, "The International Halley Watch, A Program of Coordination, Cooperation and Advocacy," Pasadena, NASA-JPL, 1981.

## ORGANIZATION AND STAFF OF THE IHW

The purpose of the IHW organization is to promote communication and cooperation among scientists interested in comets in pursuit of its goals of advocacy, coordination, standardization, and archiving. It is intended that existing ties and cooperation among scientists be strengthened and new ones promoted while avoiding creation of a hierarchical command structure. The organization chart shown in Fig. 1 should be viewed as an information flow chart, a chart showing lines of communication.

The most important elements in the IHW are the Professional Observers and the Discipline Specialist Teams. Without the Observers, there can be no Halley Watch, and without the Discipline Specialists (DSs), there would be no coordination of observations. Experts have been selected for seven DS Teams in each of seven areas of astronomical technology. Their first job, now under way, is to assemble nets of observers willing to observe P/Halley using those techniques. The DSs, in consultation with their net members, will recommend standards, data formats, and objectives and priorities for observations. In short, the DS teams each will coordinate the activities of observers using a particular observing technique. The intent is to maximize the scientific value of all Halley observations worldwide without unduly constraining the prerogatives of the individual observers. The DS teams as presently constituted are given in Table 1. Each team member is supported by his own government and/or university.

The Lead Center Organization (LCO) consists of two offices, one in Pasadena, California, U.S.A., and one in Bamberg, FRG. The primary purpose of the LCO is to coordinate activities among the various disciplines and between the IHW and various flight projects. The LCO will coordinate amateur activities as described in a separate article. The LCO will store all Halley data and ultimately produce the Halley Archive. To a large extent all of these activities will be carried out in parallel in Pasadena and Bamberg. This will serve to ease communication problems caused by the nine-hour time difference between Europe and California and also offers assurance that the IHW can and will be brought to a successful conclusion, even in the event of some catastrophe (natural or financial). Financial support of the Pasadena and Bamberg offices comes from the U.S. and West German governments, respectively. The LCO described is illustrated in Fig. 2.

The IHW Steering Group (SG) serves in an advisory capacity to the LCO, making available many years of experience in the problems of cometary science and international cooperation. The SG selected the DSs and will continue to meet with them at least once each year to review the development of the

observing nets. The advice of the SG already has proven invaluable in advancing the IHW along its intended path. Its current membership is shown in Table 2.

It is recognized by the Halley flight projects, Giotto, Vega, and Planet-A, that their chances for success will be greatly improved by mutual cooperation and by cooperation with the IHW. An Interagency Consultative Group met for the first time in Padua, Italy, in September 1981, to discuss such cooperation. The organization shown in Fig. 3 is the outgrowth of that meeting. IHW Project Representatives listed in Fig. 2 have been designated by each flight project to serve as single path communication links. The IHW will supply the flight projects with ephemeris data and will place the brief spacecraft encounters with Halley into the context of the entire apparition. The flight projects will supply their scientific results to the Halley Archive and will support the ground-based efforts of the IHW in every way that is useful and possible.

Potential earth-orbiting Halley studies using the Space Telescope or shuttle-borne instruments will be treated as flight projects as they come into being. Aircraft, balloon, or sounding rocket studies will be treated as ground-based and a part of the appropriate discipline.

The formal staff of the IHW is small and, we hope, efficient. Its purpose is to aid the world's astronomers in their study of P/Halley. Any suggestions of how this might be better accomplished will be welcomed by the undersigned.

R. Newburn

J. Rahe

# DISCIPLINE SPECIALIST TEAMS

| | | |
|---|---|---|
| ASTROMETRY | D. K. YEOMANS | JPL |
| | R. M. WEST | ESO |
| IR SPECTROSCOPY & RADIOMETRY | R. F. KNACKE | SUNY (STONY BROOK) |
| | T. ENCRENAZ | OBS. - MEUDON |
| LARGE-SCALE PHENOMENA | J. C. BRANDT | GSFC |
| | M. B. NIEDNER | GSFC |
| | J. RAHE | OBS. - BAMBERG |
| NEAR-NUCLEUS STUDIES | Z. SEKANINA | JPL |
| | J. RAHE | OBS. - BAMBERG |
| | S. LARSON | U. OF ARIZONA |
| PHOTOMETRY & POLARIMETRY | M. A'HEARN | U. OF MARYLAND |
| | V. VANYSEK | CHARLES U. |
| RADIO STUDIES | W. M. IRVINE | U. OF MASS. |
| | F. P. SCHLOERB | U. OF MASS. |
| | E. GERARD | OBS. - MEUDON |
| | R. D. BROWN | MONASH U. |
| | P. GODFREY | MONASH U. |
| SPECTROSCOPY & SPECTROPHOTOMETRY | S. WYCKOFF | ARIZ. ST. U. |
| | P.A. WEHINGER | ARIZ. ST. U. |
| | M.C. FESTOU | S. D'AERONOMIE CNRS |

Table 1

# IHW STEERING GROUP MEMBERS

| NAME | | RESIDENCE | NAME | | RESIDENCE |
|---|---|---|---|---|---|
| M. K. V. BAPPU | - | INDIA | A. MASSEVITCH | - | USSR |
| M. J. S. BELTON | - | USA | C. R. O'DELL | - | USA |
| J. BLAMONT | - | FRANCE | R. REINHARD | - | THE NETHERLANDS |
| G. BRIGGS | - | USA | H. E. SCHUSTER | - | CHILE |
| A. DELSEMME | - | USA | V. VANYSEK | - | CZECHOSLOVAKIA |
| B. DONN | - | USA | J. F. VEVERKA | - | USA |
| H. FECHTIG | - | WEST GERMANY | K. W. WEILER | - | USA |
| I. HALLIDAY | - | CANADA | G. WETHERILL | - | USA |
| G. HERBIG | - | USA | F. L. WHIPPLE | - | USA |
| Y. KOZAI | - | JAPAN | L. L. WILKENING | - | USA |
| R. LUST | - | WEST GERMANY | YA. S. YATSKIV | - | USSR |

Table 2

IHW ORGANIZATION

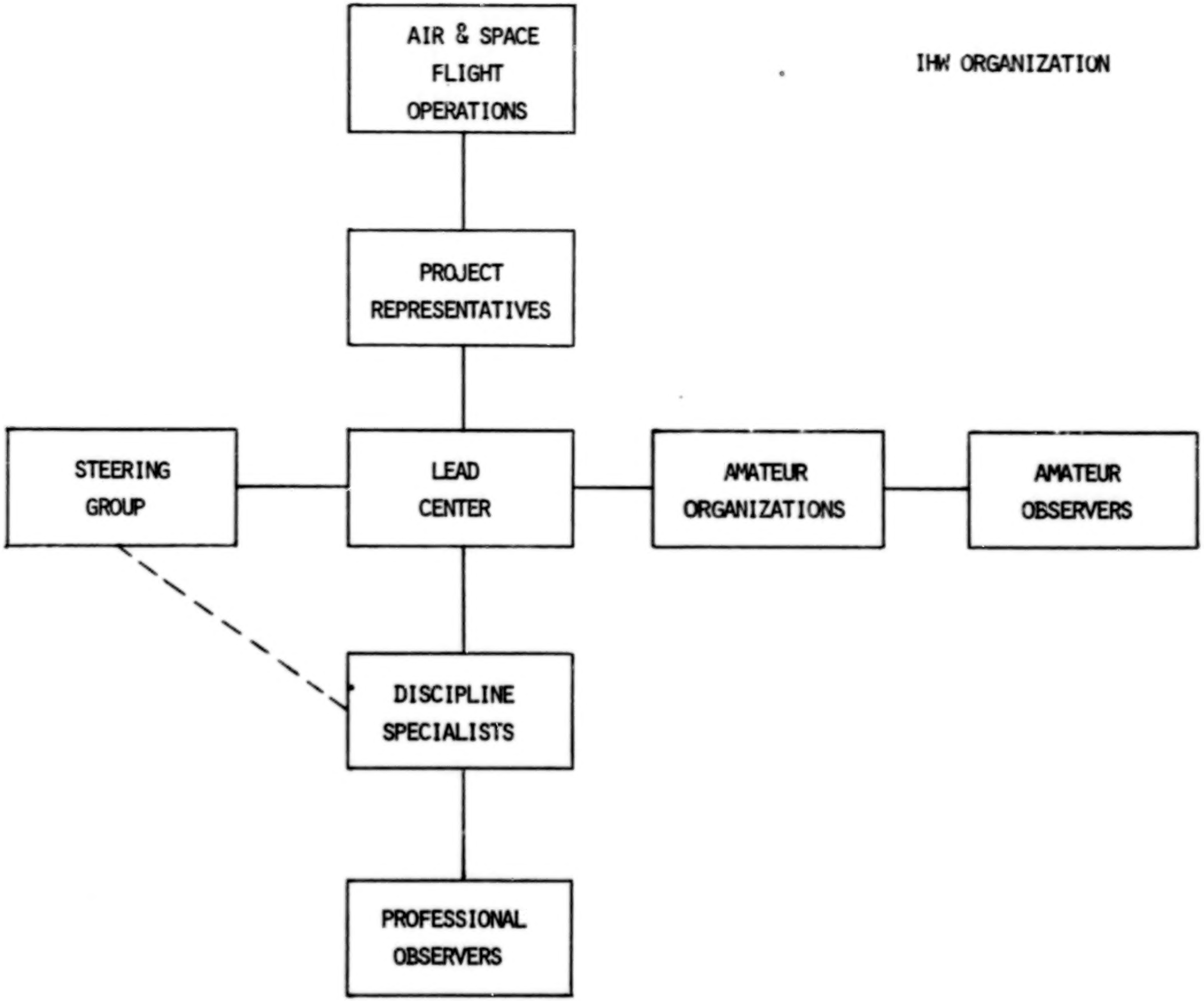


Figure 1

## LEAD CENTER ORGANIZATION

LEADERS - R. NEWBURN, J. RAHE

DEPUTY LEADER - M. GELLER

ADMINISTRATOR - L. W. CARLS

ARCHIVE EDITOR - Z. SEKANINA

COMPUTER SCIENTIST - L. ELSON

COORDINATOR FOR AMATEUR OBSERVATIONS - S. J. EDBERG

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## PASADENA OFFICE

MANAGER - R. NEWBURN

## BAMBERG OFFICE

MANAGER - J. RAHE

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## PROJECT REPRESENTATIVES

| | |
|---|---|
| GIOTTO | R. REINHARD |
| PLANET-A | K. HIRAO |
| VEGA | R. SAGDEEV (ACTING) |

Figure 2

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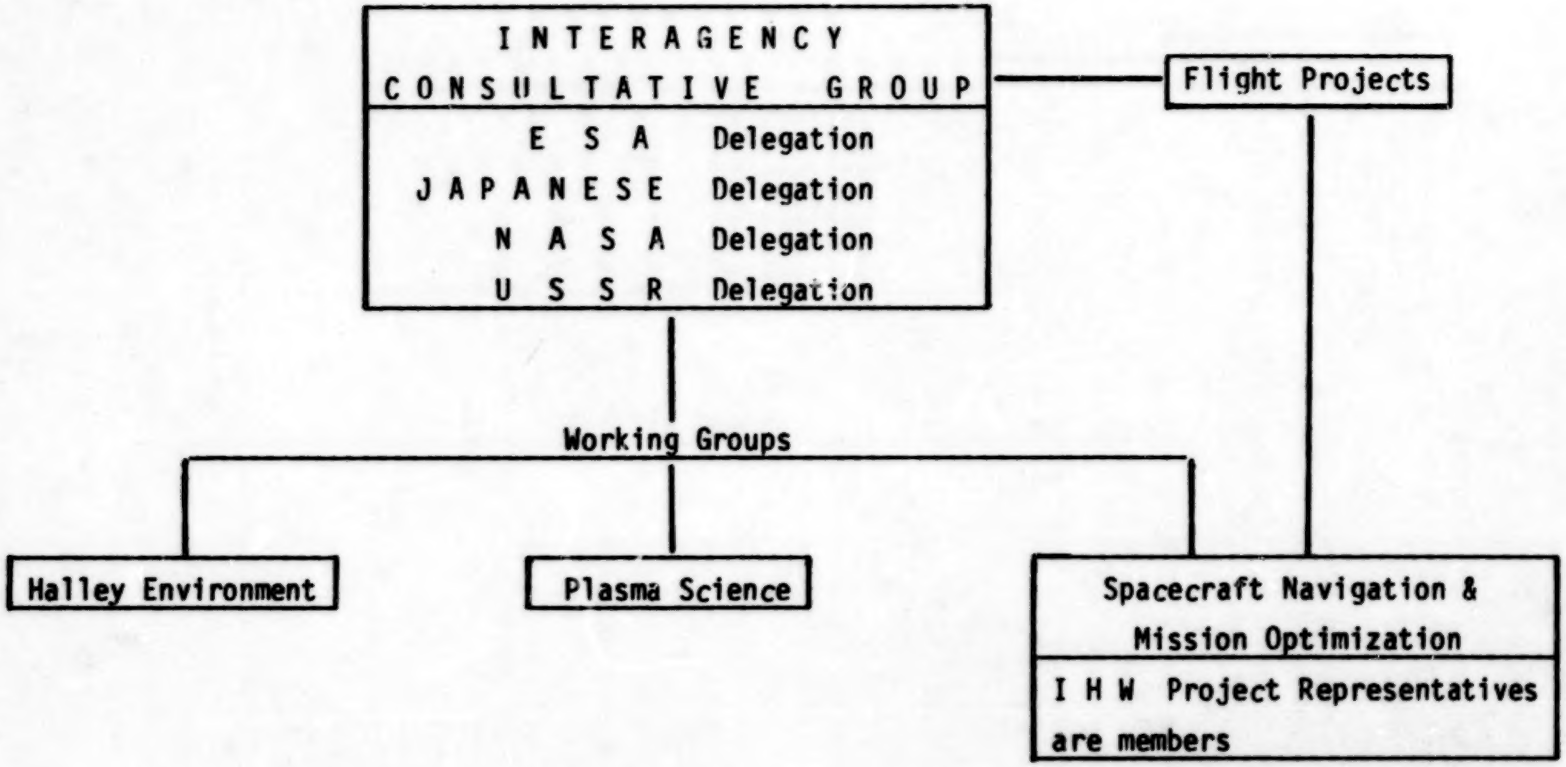
I N T E R A G E N C Y
C O N S U L T A T I V E   G R O U P
E S A Delegation
J A P A N E S E Delegation
N A S A Delegation
U S S R Delegation
Flight Projects
Working Groups
Halley Environment
Plasma Science
Spacecraft Navigation & Mission Optimization
I H W Project Representatives are members

**Figure 3**

## DATA RIGHTS AND THE HALLEY ARCHIVE

The question most often asked by astronomers hearing about the IHW for the first time is "Why should I give you my data?" In many cases, the answer is "We don't want your data until after you have already published it in the normal manner." In the real world of the IHW, in fact, there will be many different arrangements with observers. In the Astrometry Discipline, observers will measure Halley's position the minute the plates are dry and transmit all data immediately, for the sake of ephemeris calculations for the flight projects. Publication of the positions will still take place in a traditional manner, however. Some observers may choose to transmit information to help other observers and the flight projects while retaining all publication rights. Other observers may simply take data as a courtesy, supplying it uninterpreted to the IHW as reduced or even raw data. In some areas, observers may choose to work as one large team, with joint publication in a journal of choice with the reduced data sent to the IHW by Jan. 1, 1988. In all cases, data transmitted to the IHW will include a code in the data bank indicating the release status. Unless we have definite evidence to the contrary, that code will always indicate "do not release before 1988."

It is the intent of the IHW to publish an archive of all Halley observations taken during the 1986 apparition. Actual publication is expected to occur in 1989 under the editorship of Dr. Zdenek Sekanina. The archive will not be a collection of interpretations, of ordinary papers, although an index to published papers might be furnished. The archive will consist of reduced data, probably arranged chronologically. How many $Wm^{-2}$ at wavelength $\lambda$ were received through a diaphragm of X arc sec diameter at time t, etc. Since quantitative imaging data and some spectra can not readily be presented in book form, these may be included on video discs.

The format of the archived data in each discipline will be worked out jointly by the discipline specialists and the astronomers cooperating with them. If the format is inconvenient for some observers, the discipline specialist will accept what is available and format it. Standardization also will be the product of joint agreement, but no one will be "forced" to accept particular standards in order to participate in the IHW. We hope, for example, that photometry specialists will see that it is to everyone's advantage to take at least part of their data using standard filters, filters which in some cases can even be supplied by the IHW. The IHW will archive all properly documented photometry whether standardized or not.

One goal of the IHW is to see P/Halley studied as no comet has ever been studied before, with thorough coverage by all practical means throughout the apparition. Another goal is to see the observations of P/Halley gathered together in a single archive for the use of current and future scientists in deriving a clearer picture of the nature of the phenomenon called a comet. These goals can only be achieved by worldwide cooperation in the best traditions of astronomy as exemplified by the IAU.

R. Newburn

J. Rahe

## ASTROMETRY

The Astrometry Network of observers will provide the accurate astrometric and nucleus magnitude data that are required for orbit and ephemeris computations, for dynamical modeling of the rocket effect due to the comet's outgassing, and for estimates of the comet's photometric cross section. The astrometric observations of the comet will be made from the comet's initial recovery until the last successful observation after perihelion. These observations will be used to continually update the comet's orbit and ephemeris— a function that is important for supporting ground-based observations of the comet and critically important for supporting the flyby spacecraft of the European Space Agency (ESA), Japan, and the Soviet Union. Astrometric observations will also allow refinements in the existing model for the so-called nongravitational forces affecting the motion of Comet Halley. These forces are thought to be due to the rocket-like thrusting of the outgassing icy nucleus. Data on the apparent nuclear magnitudes of an inactive Comet Halley at great heliocentric distances will allow a determination of the comet's photometric cross section, i.e., geometric albedo x (effective nuclear radius)$^2$.

Using the astrometric data, the Office of the Astrometry Discipline Specialist will generate and distribute various types of ephemeris data to observers using ground-based and earth orbital instrumentation. ESA will send its Giotto spacecraft past comet Halley on March 13, 1986, and the Soviet Union and Japan plan to send two spacecraft apiece past the comet at about the same time. An accurate Comet Halley ephemeris for these three flight projects will depend upon an experienced and well-coordinated group of astrometric observers. Comet Halley will be in solar conjunction from mid-January to late February 1986, so that only a week or two of astrometric data will be available to update the comet's ephemeris prior to the final mid-course maneuver of each spacecraft. Hence, experienced astrometric observers who have the facilities for rapid data reduction are particularly important to the success of these flight projects.

The Discipline Specialists for Astrometry will be Dr. Donald K. Yeomans and Dr. Richard M. West. Dr. Brian G. Marsden of the Smithsonian Astrophysical Observatory and Dr. Robert S. Harrington of the United States Naval Observatory are acting as scientific collaborators.

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INFRARED SPECTROSCOPY AND RADIOMETRY

The 1986 apparition of Comet Halley provides an opportunity for infrared observers to investigate cometary gases and dust. Clarifying a number of long-standing questions about the nature of comets, processes in the formation of the solar system, and the relation of comets to the interstellar medium are major goals. In early, exploratory work, the power of infrared techniques in cometary studies was demonstrated with, for example, studies of the evolution of thermal emission in several comets (Ney, 1974) and the identification of silicate dust in comets Bennett and Kohoutek (Mass et al., 1970; Merrill, 1974). Improvements in infrared instrumentation since the early 1970's promise considerably greater sensitivity for Halley observations, and consequently much more information about comet structure and composition should now be accessible.

At this time, no molecular bands have been unambiguously established in infrared spectra of comets despite the presence of strong vibration-rotation bands in the spectra of molecules of greatest interest, such as $H_2O$, $NH_3$, $CH_4$ and their fragments. The problem has been one of sensitivity, but with new techniques such as grating spectrometers with multichannel detection systems now becoming operational, the infrared should become the source of significant new information complementing what has been learned from the ultraviolet, visible, and radio spectral regions. A limited number of high-resolution observations with Fourier transform spectrometers should also be possible with a bright comet like Halley. A great deal will be learned if the IHW infrared net can follow Halley and record both photometric and spectroscopic developments as the comet passes through the inner solar system.

The composition of cometary ices is presently inferred indirectly through observation of daughter products such as $H_2O^+$. The infrared opens up the possibility of observing the ices directly through detection of infrared solid bands, perhaps similar to those observed in interstellar dust. Searches for water and methane ices in the middle-infrared have already begun with interesting results (A'Hearn et al., 1981). Halley, being much brighter than the comets searched for ice so far, may give us detailed information about cometary ices and their volatile content. Such studies have wide-ranging implications for the understanding of the composition of the outer solar system, including the atmospheres of Titan, Uranus, and Neptune, and may be relevant to the evolution of the earth's atmosphere.

In addition, more work needs to be done on the cometary silicates. How similar are they to interstellar silicates, to meteoritic silicates, or to particles condensed in laboratory simulations? What is the connection with Brownlee particles? What other nonvolatile compounds are present? Since micron-sized particles are best studied in the infrared, cometary dust will be a natural target for the IHW Infrared Net.

Structural information will also be a goal of the infrared net. Imaging of the comet with modern techniques should be very interesting. The comet should be studied over as much of the orbit as possible. Heating and chemical reaction processes depend on the heliocentric distance and should be followed in the infrared. If, for example, the nucleus is layered, the stripping of

the surface as it ablates could be observed. Particle size will be measured as a function of time.

The scientific objectives of the International Halley Watch are to characterize the structure, basic physical processes, and chemical nature of cometary nuclei, atmospheres, and tails, and to determine the changes that occur as a function of time and position. Advances in technology suggest that infrared observations will contribute to all of these objectives. We invite interested observers to participate in the unique opportunity afforded by the Halley apparition.

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References

A'Hearn, M. F., Dwek, E. and Tokunaga, A. T. 1981, Ap. J. (Letts), in press.

Maas, R., Ney, E. P. and Woolf, N. J. 1970, Ap. J. (Letts), 160, L101.

Ney, E. P. 1974, Ap. J. (Letts), 189, L141.

## LARGE SCALE PHENOMENA

A worldwide network of ground-based observatories with wide-field imaging capability will be of inestimable value in the study of Halley's Comet in 1985/1986. It will

1) provide a set of images of high time resolution necessary for a detailed study of highly variable plasma-tail phenomena,

2) permit the "calibration" of plasma-tail events with solar-wind properties (measured in situ by the Halley missions and by near-Earth spacecraft) required for the general use of comets as solar-wind probes, and

3) serve as a "barometer" of the large-scale state of the comet as the Giotto, Venera, and Planet-A spacecraft fly by, thus assisting the interpretation of the in situ data.

The need for the network approach has been recognized for many years. Commenting on the spectacular and unusual tail structures seen in a photograph he had taken of Comet Morehouse on 15 October 1908, structures which were not visible in Yerkes Observatory photographs taken the previous night, E. E. Barnard had the following to say:

"Photographs of the comet...made in the early evening of the 15th in England or on the continent ought to show the masses quite close to the head of the comet... It will be a great pity if photographs were not made in Europe to give a complete history of the transformation of some of these masses throughout their visible existence."

Thus, as Barnard recognized, the great changes in the tail were much too rapid to follow from photographs taken on successive nights at one (namely, Yerkes) observatory, and greater coverage was needed. Fortunately, Pidoux, at the Observatory of Geneva, and Quenisset, at Juvisy Observatory, had both secured photographs early on October 15 which did show an earlier stage of development of the tail disturbance.

The event recorded by Barnard, Pidoux, and Quenisset is one of a general class of tail structures known as disconnection events (or DE's), in which the entire plasma tail uproots itself from the head of the comet, recedes in the anti-sunward direction, and is replaced by a "new" plasma tail. The phenomenon—by no means confined to anomalous Comet Morehouse—was well-known to Barnard and his contemporaries, and it is undoubtedly the most spectacular wide-field phenomenon exhibited by comets. At least five DE's are known to have occurred in Halley's Comet during the 1910 apparition; given the rapidity of the phenomenon, a proper study of DE's in 1985/1986 will require a worldwide network.

Halley's is one of a class of comets which display prominent plasma ("type I") and dust ("type II") tails simultaneously. In most of the discussion which follows, however, we will be emphasizing plasma-tail phenomena since the associated timescales for major change are much less than those of dust phenomena. Although a network is probably not essential for the study of the dust tail, an added benefit of having an effective wide-field network would be the existence of images suitable for such studies.

Comets of Halley's brightness generally have plasma tail lengths greater than $2 \times 10^7$ km for heliocentric distances less than 1 AU. With this assumption, angular lengths approaching 8°-10° are expected especially when the comet is a southern hemisphere object in 1986 March-April. Thus, cameras with field-of-view $\gtrsim 5°$ will be the most productive instruments for the wide-field imaging of the tail. The period of closest approach to Earth - 1985 late-November (northern hemisphere) and 1986 early-April (southern hemisphere) - occur at large r (1.55 and 1.33 AU, respectively), where both the tail's brightness and linear extent are difficult to predict.

Plasma tails radiate principally via resonance fluorescence of the $CO^+$ molecule whose strong band system at $\lambda$ 4273 dominates the spectral response range of blue-sensitive photographic plates. Our experience is that unfiltered IIa-O plates yield very satisfactory results. The correct exposure times for plasma-tail photographic imaging is less a matter of calculation than of experimentation. Generally speaking, however, a fast system like the Comet Schmidt (f/2) at the Joint Observatory for Cometary Research (JOCR) records deep, usable tail images on unfiltered IIa-O in 3-10 minutes for the inner tail regions; whereas the most distant tail regions usually require exposure times $\gtrsim$ 20 minutes.

The network goal is to obtain wide-angle images at approximately one hour intervals for extended periods during the prime observing periods from earth, roughly November-December 1985 and March-April 1986, and during the period of spacecraft closest approach, roughly March 7-16, 1986. As a preparatory action, we have in the last three years sent out several calls for support, and the responses have been very encouraging: $\gtrsim$ 40 observers/institutions around the world have indicated a desire to collaborate with us in a wide-field network for Halley observations. A large fraction of the proposed instruments are fast (~ f/2) Schmidt cameras (typical FOV = 5°-10°), which are probably the ideal (but not the only useful) telescope for wide-field imaging of the plasma tail, an extended (~ 10°) object of moderate to low surface brightness. One of our present concerns is the lack of coverage near ~ 75° E (India) and between 15°-45° W (W. Africa - E. Brazil). Telescopes in either of these longitudinal ranges would be of particular use to our planned program. In consideration of uncertainties caused by weather, we of course welcome the addition of observers/instruments to our net anywhere.

Participating institutions are asked to forward data (in this case, film copies of the best plates or, when possible, the original plates) to us for reduction and analysis in the context of the worldwide data as a whole, and for inclusion in the Halley Archive, but—and this goes without saying—they retain full proprietary rights to the analysis of their own data. This arranngement has seemed very satisfactory and fair to most of the observers and institutions we have contacted.

Far from regarding the present wide-field network as complete, we consider it only a "good start." We welcome your support in this very important scientific venture.

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M. B. Niedner
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## NEAR-NUCLEUS STUDIES

The purpose of the Network for Near-Nucleus Studies is to provide the observational basis for an in-depth investigation of the large-scale surface morphology of Halley's nucleus, its thermophysical properties, spin-axis orientation, and rotation period.

Halley's nucleus is believed to be structurally nonhomogeneous, the source of the comet's well-known outgassing asymmetry. This asymmetry is

reflected in the anisotropic distribution of dust in its atmosphere and is observed as discrete coma structure such as jets, shells, envelopes, etc. These features vary considerably from day to day but do not necessarily show perceptible motions during the usually short observing window accessible from a single observatory. It is therefore essential that the Network for Near-Nucleus Studies be well-distributed in longitude. High resolution images of the near-nucleus region obtained by the Network will eventually be analyzed by computer techniques. The goal is to produce a map of the active areas on the nucleus based on systematic changes in the pattern of the discrete dust phenomena.

The proposed collaborative effort of the Network members will be the first organized attempt of its kind. The advocated extensive temporal coverage is essential for the proper interpretation of the individual observations and for the understanding of the global morphology of Halley's nucleus. Since the fly-through spacecraft will provide only a snap-shot view of the nucleus, the interpretation of these data should be facilitated by comprehensive information from the Near-Nucleus Studies Network.

The peak activity of the Network is expected to take place in late 1985 through the middle of 1986. Special campaigns of intensive observation will be organized at critical times when the comet is well placed for observing, and during spacecraft encounters to supply valuable support data.

Halley provides us with the unique opportunity of studying the most important part of every comet—its nucleus. It is imperative that this opportunity not be missed.

The Discipline Specialists for the Near-Nucleus Studies are Drs. Jurgen Rahe (whose primary responsibility will be the Network's organization in Europe, Asia, and Africa) and Zdenek Sekanina (responsible chiefly for North and South America, Australia, and Pacific islands) and Mr. Stephen M. Larson.

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PHOTOMETRY AND POLARIMETRY

The photometry and polarimetry net has several related goals, some of them connected with our own research interests and some of them as a service to the rest of the astronomical community. We hope to have some observers participate in observations with standardized techniques which will provide homogeneous data that can be combined from different sites and compared with results from other nets such as radio or infrared. In additon, we hope that other observers will carry out programs of their own design but basically in coordination with the standardized observing so that standardized data can be provided for the time of their observations. We will describe first some of the standardized observations.

The first of the standardized programs will involve filter photometry of the comet with a variety of different diaphragms but with standard interference filters. Observations at selected intervals of heliocentric distance by several observers at different longitudes (to be reasonably sure of not losing data due to bad weather) will enable us to study the variation in the production of different gaseous species as a function of heliocentric disance, and particularly to look for asymmetries between the pre- and postperihelion phases. These data will also enable us to study the changes in the continuum-to-emission ratio and any changes in the color of the continuum. The filters for these studies will be provided by the IHW. As noted above, it will be necessary to have observers at different longitudes in order to assure that weather does not prohibit observations at certain heliocentric distances, and it will also be necessary to have observers in both northern and southern hemispheres because of the wide range of declinations covered by Halley during this apparition. We envision using a few large telescopes when the comet is faint (from late fall 1984 to early fall 1985 and early summer 1986 to summer 1987) and a somewhat larger number of smaller telescopes when the comet is brighter (fall 1985 through summer 1986). Halley should provide us with a unique opportunity to determine production rates over a wide range of perihelion distances and to look for differences between the pre- and postperihelion phases. This in turn will allow us to place severe constraints on the vaporization process and on the chemical processes that produce the observed species in the coma. We anticipate that some observers may obtain sufficient data to study these questions based on just their own data, and they would, of course, be encouraged to do so. The role of this office will be to consider the synthesis of the data. A simple example of this type of program can be seen in a paper by A'Hearn, Millis, and Birch (1981, A. J. 86, 1559) which combined observations of Comet Bradfield, 1979X, from three different observatories to obtain a light curve. Comet Halley will enable us to study a much wider range of heliocentric distances than was possible for Bradfield, in addition to providing both pre- and postperihelion data.

Closely related to this study will be the study of outbursts, which now seem to be a relatively common phenomenon among comets. When the comet is fairly bright, say in late 1985 and early 1986, on certain designated periods of two or three days we will attempt to obtain filter photometry from as many different longitudes as possible in order to study the changes which take place during an outburst. If a number of such periods are select-

ed, presumably coincident with the attempts to determine the heliocentric distance variation, we are likely to observe an outburst on one or more of those occasions. Since a typical outburst only lasts a few days at most (except in comets like P/Schwasmann-Wachmann 1 which is unusual because of its great heliocentric distance), the wide coverage in longitude will provide us with the first detailed study of the time variation during an outburst. In both of these programs, the study of the heliocentric distance variation and the study of outbursts, we expect that the Discipline Specialist will participate as a normal member of the observing net as well as providing advice and standardization to all members of the net. As with all nets, individual observers will be encouraged to publish their own results in addition to participating in the synthesis of the data from many observers.

We also hope to encourage systematic measurements of the polarization of the continuum of the comet, again using standardized filters which isolate various portions of the continuum, and again using a variety of sites in order to ensure observations which are well-spaced in time (to look for changes in the nature of the particles released) and which are well-spaced in phase angle (to study the scattering function of the particles). Again the role of the Discipline Specialist will be to provide some coordination and synthesis, but in this case we will rely on the participating experienced photometrists to both carry out the observations and do the analysis.

One other type of coordinated program seems to be appropriate, and that is an attempt to study the optical depth of the grains in the comet by means of occultations of stars by the comet. The occurrence of occultations will be predicted by the astrometry net of the IHW, and, for opportune ones, we will attempt to organize teams of observers with portable equipment to monitor the occultations, much as has been done for occultations by asteroids.

Observations of the attenuation of the starlight along several chords through the cometary coma provide the only means for directly determining the optical depth of the coma in the continuum. Simultaneous measurements of the surface brightness will yield directly the scattering function of the particles for that particular scattering angle.

All of these standardized programs, however, should not deter people from considering their own photometric and polarimetric programs which do not fit into any of these standard programs. We anticipate that many observers will have special measurements that they wish to make (e.g., intensities of certain weak spectral features, spatial profiles of surface brightness, etc.). If these measurements are coordinated with the standard observing programs, the observer can be assured that at the time of his observations there will also be other data available regarding production rates of gas and dust and the polarization in standard bandpasses. In many cases, the availability of contemporaneous standardized data can greatly assist in the interpretation of unique results.

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## Reference

A'Hearn, M. F., Millis, R. L., and Birch, P. V., A. J. 86, 1559.

## RADIO SCIENCE

There is great potential for Radio Science studies of a bright comet coming under predictable circumstances. Observations of radio frequency spectral lines from molecules in the coma can provide unique information about the composition of the nucleus, continuum observations may reveal the nature of particulate material and/or complex plasma processes in the coma, and radar studies have the potential of directly measuring the size and surface properties of the nucleus.

Until now only the OH transitions at 18 cm wavelength have been repeatedly observed in comets, providing fundamental data on production rates and flow velocities and serving to indirectly confirm the importance of $H_2O$ as a major constituent of the nucleus. Radio detections of many other types have been claimed including thermal emission and spectral lines of the important HCN and $CH_3CN$ molecules, but they have often not been confirmed in subsequent comets or even in the same comet at different times. This behavior is typical of astronomical phenomena at the limit of existing sensitivity, but it may also be typical of the behavior of comets, which are well-known to be highly diverse and time variable. Fortunately, both new, powerful radio telescopes and increasingly sensitive receivers are now becoming available. The International Halley Watch hopes to ensure that the most sensitive radio facilities in the world will participate in coordinated observations so that the promise of ground-based radio observations of comets may actually be realized.

Spectral lines at $\lambda > 0.5$ mm arise mainly from molecular rotational or hyperfine transitions and may be used to probe the chemical composition of the gas phase coma. Such measurements thus provide a means of studying the nature of the parent molecules sublimating from the nucleus into the coma, the chemical processes in the coma itself, and the production and dispersal of molecular ions into the tail. Analysis will provide fundamental information on the conditions under which comets were formed including the physical and chemical state of the condensing solar nebula, the nature of interstellar grains and gas, and (more speculatively) the early stages of chemical evolution and the origin of life.

The determination of molecular abundances from radio measurements is a difficult problem. Quantitative results demand simultaneous observations of multiple transitions of the same molecule, preferably with similar spatial resolution and (if possible) including isotopic variants. Nonequilibrium excitation is known to occur for OH via solar UV radiation, and such population inversions may be important for other molecules as well. Monitoring the temporal behavior of any emission, both as a function of heliocentric distance and velocity and during "flares" or other sporadic phenomena, will be particularly important to the unraveling of such questions.

Continuum cometary radio emission may in principle arise either as thermal emission from solid particles in the coma (ice or dust) or as non-thermal emission produced by plasma effects. Reports of both phenomena have been published. Confirmation and study of the radio continuum emission would thus provide important basic data on the nature, spatial distribution, and temporal behavior of particulate matter including the hypothesis of an icy grain halo and on the poorly understood plasma processes in comets.

Radar detection of Comet Halley would be very valuable but also very difficult. Information about the size, surface structure, and rotation of the nucleus could all be obtained in this way, and even upper limits on the nuclear size might place useful constraints on cometary models. However, it seems rather unlikely that any presently existing radar system could detect an echo unless the nuclear radius is larger than about 4 km (which is at the upper limit of present size estimates). Nonetheless, both the Arecibo Observatory (the world's largest radio-radar telescope) and the NASA Goldstone antenna are in the planning for radar observations.

Since all radio science observations are severely technology-limited for Comet Halley, it is imperative to mobilize significant participation by the most powerful radio astronomical facilities that will be functioning in 1985-86. We note that it will be especially important to involve southern hemisphere observatories in the net since the comet will be very far south after perihelion and unobservable in the Northern hemisphere during its closest approach to the Earth. Rapid developments in receivers at the very highest radio frequencies also point out the critical importance of using some telescopes, designed primarily for shorter wavelength observations, at millimeter and submillimeter wavelengths as well, where rotational transitions of small molecules have large line strengths.

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## SPECTROSCOPY AND SPECTROPHOTOMETRY

For the first time, observers will have the opportunity to plan well in advance for the reappearance of a bright, active comet having both an accurately determined orbit and spectroscopic observations from a previous apparition. Comet Halley may be spectroscopically observable as early as October 1983 (heliocentric distance ~ 9 AU) and for a few subsequent years as the comet approaches and recedes from perihelion in February 1986.

Some specific goals of spectroscopic observers in the International Halley Watch (IHW) will be (1) to observe the comet over as large a range in heliocentric distance as possible, (2) to identify new chemical species, (3) to monitor production rates and column densities of various chemical species, (4) to determine abundances of as many species as possible, (5) to measure scale lengths of various molecules, atoms, and ions using long-slit spectroscopic techniques, and (6) to map the velocity field of the expanding coma and the plasma tail using high resolution spectra. From such observations of comet Halley we may expect to determine its chemical composition, evolutionary history, and the nature of the comet's interaction with the solar wind and radiation.

The objectives of the IHW in spectroscopy and spectrophotometry will be to organize and coordinate a world-wide network of spectroscopic observers in order to optimize the scientific returns of the pending apparition of comet Halley. The Discipline Scientists in Spectroscopy and Spectrophotometry, Susan Wyckoff and Peter Wehinger (Physics Department, Arizona State University, Tempe, AZ, USA) and Michel Festou (Service d'Aeronomie CNRS, Verriefes le Buisson, France) are interested in contacting observers during the IAU General Assembly who are interested in participating in the spectroscopic network of the IHW. One of our first goals as Discipline Scientists will be to assemble a list of potential spectroscopic observers who wish to receive more information concerning the coordination of spectroscopic observations of comet Halley. We wish to make both informal contacts during the General Assembly and to encourage interested astronomers to respond by filling out the form at the end of this newsletter. Spectroscopic observers expressing an interest in the IHW will receive additional information in the form of personal letters from us and the IHW Newsletter which will be mailed on a regular basis from the Halley Watch Lead Center in Pasadena.

Hence, it is our purpose at this time to solicit interested observers in order that a preliminary mailing list of interested spectroscopic observers of comet Halley can be compiled. Among the first priorities of our future correspondence with observers on the mailing list will be to explain the goals and organization of the network for spectroscopic and spectrophotometric observations of comet Halley, to poll observers concerning spectroscopic instrumentation which will be available at various observatories throughout the world during the comet's apparition in 1983-87, and to establish communication links by compiling telephone and telex numbers of various observers cooperating in the IHW.

We wish to encourage astronomers to cooperate in this unique opportunity to study comet Halley and strongly urge the participation of all spectroscopic observers in the IAU. To aid in compiling a list of potential spectroscopic observers of comet Halley, we request that interested observers return the attached form to the mail boxes of S. Wyckoff or P. Wehinger during the General Assembly in Patras.

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## THE AMATEUR OBSERVATION NET

The Amateur Observation Net of the International Halley Watch (IHW) is being organized to encourage useful participation of amateur astronomers in the IHW. Amateur enthusiasm for Halley's Comet is already growing and the goal of this net is to harness this energy to supply useful primary and supplemental data. The intent is to use amateur-supplied data and the data obtained by the professional nets to provide a complete record of this apparition of Halley's Comet.

The primary goal is to obtain visual and photographic records of this apparition for direct comparison with similar data from 1910. Professional astronomers have almost completely relinquished visual comet studies while such studies are a very active pursuit among amateurs. State-of-the-art photographic techniques in 1910 are commonly available to amateurs at the present time. Thus amateurs are eminently well-suited to share in the achievement of this goal.

Because amateur astronomers have the freedom to choose when and where they observe, they can provide valuable supplementary data and occasionally primary data for analysis. Weather, observatory geographical position, telescope time allotments, and certain equipment limitations may all act to inhibit data acquisition by professional observers. The freedom mentioned earlier and the sophisticated equipment in many amateur hands, given guidance, will allow the data they collect to fill in gaps in professional coverage.

Overall coordination for the amateur net will be from the Pasadena lead center of the IHW. Each country's national amateur astronomical organization(s) will be asked to collect and appraise the observations made by their nationals before forwarding it to the Pasadena center for dispersal to the Discipline Specialists and/or Archives.

In the U. S., which lacks a national umbrella group, the lead center will appoint "Recorders" in each area of amateur participation to handle the data collection and appraisal. A similiar organization will be suggested for use in other countries.

Several methods of communication with amateur participants are planned. A regular newsletter, initially published on a quarterly basis, will provide a personal, direct mail interaction with each participant to help maintain interest. Articles and news releases will be prepared for distribution to a group of general science and astronomy magazines published around the world. Special comet sessions at amateur conventions may be organized. Finally, the looseleaf IHW Amateur Observer's Manual and revisions will be published and distributed to amateur contributors.

The Manual will serve to educate amateur astronomers about comets and some of the methods of observing them. Instruction will be given on what to study and how. Wherever possible, observation techniques will be standardized (e.g., visual magnitude and coma diameter estimates). Standard calibration procedures will be required (e.g., transparency estimates, photoelectric comparison stars). Reports on methods used will be required in areas that are not easily standardized (e.g., photographic hypersensitizing and developing). In this fashion the scientific value of the data collected by amateur astronomers will be greatly enhanced; indeed, it will make the data scientifically useful.

Five areas of study have been identified for amateur participation: visual observations, photography, spectroscopic observations, photoelectric photometry, and meteor observations. Several investigations are suggested for each of these areas in the Manual.

Visual observations include coma magnitude and diameter estimates, tail length measurements, and drawings. A proposal to establish a semi-professional discipline net to supply real-time reports of sporadic activity to the lead center has been approved. This will allow rapid communication of significant events to the professional nets.

Very wide angle (tens of degrees of arc) and high resolution color and filtered black and white photography is being encouraged. This work will supplement studies by the Large Scale Phenomena and Near-Nucleus Studies professional nets.

Low dispersion objective, nonobjective, and slit-less spectroscopy by amateurs is now possible because of the availability of large aperture diffraction gratings and prisms. This data will supplement that collected at high dispersion by the Spectroscopy and Spectrophotometry professional net.

Photoelectric photometry is being practiced by a growing number of amateur astronomers, with very modern equipment. While the cost and availability of recommended comet filters are a problem, by 1985 a number of amateurs will likely be equipped to contribute photoelectric observations including coma magnitudes, coma and tail intensity profiles, and stellar occultation data.

Observations of the η Aquarid and Orionid meteor showers, including hourly counts, altitude triangulation, velocity measurements, and spectroscopy, are studies in which amateurs will likely contribute more data than professionals. While the relation of these data to Halley's Comet is not clear, the opportunity to collect a high-quality, consistent data set should not be neglected.

The worldwide enthusiasm and interest in Halley's Comet by amateur astronomers will be harnessed at the coming apparition. Their observations will help in the interpretation of all the data collected to lead to a consistent, high quality empirical model of Comet Halley.

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